

AMENDMENTS TO THE CLAIMS

Claim 1 is amended to clarify that it includes not only single vibrator embodiments, but also multiple vibrator embodiments as intended and evidenced by original dependent claims 8, 10-11, 16-21 and 23-25.

The addition of one or more in the preamble is supported by the first sentence of paragraph 39 and the second sentence of paragraph 41.

Claims 10 and 11 are also amended. With these amendments, claim 11 clearly represents independent claim 26, written in dependent form, depending from claim 1, thereby demonstrating unity of invention. Support for the amendment to claim 10 comes from step (a) of claim 26. Turning to claim 11, support for “deconvolution matrix” may be found in paragraph 64 where it is disclosed that the deconvolution filter for multiple vibrators takes matrix form. Support for the first wherein clause comes from the preamble of claim 26. Support for “and further comprising . . .” comes from claim 26, step (f). Other amendments to claim 11 are obvious changes to eliminate possible antecedent basis ambiguity.

Finally, the claims now numbered 46 and 47 were renumbered to correct a duplicate numbering error in the application.

A complete listing of the claims reflecting all amendments made herein follows:

CURRENT LISTING OF CLAIMS

Following is a listing of all claims including amendments made in the present Office Action response.

1. *(currently amended)* A method of processing seismic data generated by one or more seismic vibrators comprising the steps of
 - (a) measuring a signal related to the vibrator motion;
 - (b) computing a vibrator signature for said measured vibrator motion signal;
 - (c) specifying a desired seismic data processing impulse response, wherein the high and low frequency portions of an amplitude spectrum of said impulse response taper to zero at a rate faster than does the high and low frequency portions of an amplitude spectrum of said vibrator signature;
 - (d) computing a deconvolution filter from the ratio of the desired impulse response and the computed vibrator signature;
 - (e) processing said seismic data using said deconvolution filter.
2. *(original)* The method of claim 1, wherein said vibrator motion signal is the vibrator ground force signal.
3. *(original)* The method of claim 1, wherein said vibrator motion signal is approximated by a vibrator pilot signal.
4. *(original)* The method of claim 1, wherein small values of an amplitude spectrum of said impulse response are set equal to a threshold value.
5. *(original)* The method of claim 1, wherein small values of an amplitude spectrum of said impulse response are set less than a threshold value.
6. *(original)* The method of claim 1, wherein the vibrator signature is computed from the time derivative of said ground force signal.
7. *(original)* The method of claim 1, wherein said computation of said deconvolution filter involves an iteration in which zero phase and minimum phase

impulse responses are analyzed to determine the suitability of said deconvolution filter to process high and low frequency data content in said seismic data.

8. *(original)* The method of claim 1, wherein a plurality of seismic vibrators is used, and a resulting matrix of vibrator signatures is inverted and used to determine said deconvolution filter.

9. *(original)* The method of claim 1, wherein a small amount of pre-whitening noise is added to all frequency values of an amplitude spectrum of said impulse response

10. *(currently amended)* The method of claim 1, wherein a plurality of vibratory sources are used to generate seismic data and a plurality of detectors are used to record the seismic data, wherein each vibrator is excited with a frequency sweep, and further comprising measuring a vibrator motion signal for each vibrator.

11. *(currently amended)* The method of claim 10 wherein the plurality of vibrators are excited with a number of sweeps at least equal to the number of vibrators, and wherein a full solution involving all ~~matrix~~ components of the matrix is generated by using one filter for all sweeps in a fully coupled derivation of the a full deconvolution matrix solution, and further comprising separating the data according to the individual vibrators using said deconvolution matrix.

12. *(original)* The method of claim 1 wherein the frequency sweep increases linearly in time.

13. *(original)* The method of claim 1 wherein the frequency sweep decreases linearly in time.

14. *(original)* The method of claim 1 wherein the frequency sweep is a nonlinear sweep

15. *(original)* The method of claim 1 wherein the frequency sweep is a random sweep

16. *(original)* The method of claim 10 wherein different vibrators are energized by different sweeps which are phase encoded.

17. *(original)* The method of claim 10 wherein different vibrators are energized by sweeps in which one vibrator a time is energized by a sweep with a 90 degree phase rotation relative to the phases of the other vibrators

18. *(original)* The method of claim 10 wherein multiple sweeps are used and the sweeps include phase rotations of $360/N$ degrees where N is an integer.

19. *(original)* The method of claim 17 wherein multiple sweeps are used and the sweeps include phase rotations of $360/N$ degrees where N is an integer.

20. *(original)* The method of claim 10 wherein the different vibrators are energized by sweeps covering different frequency ranges at different times.

21. *(original)* The method of claim 10 wherein the different vibrators are energized by sweeps which start at different times.

22. *(original)* The method of claim 1 wherein the location of the detectors is selected from the group comprising detectors on the surface of the earth, detectors suspended in the water, detectors on the water bottom, detectors in a wellbore, and any combination thereof.

23. *(original)* The method of claim 10 further comprising:

(a) separating the data from each vibrator into individual records for each source location;

(b) applying static corrections and differential normal moveout (NMO) correction to each source location;

(c) summing the data for each source location.

24. *(original)* The method of claim 10 further comprising (a) separating the data from each vibrator into individual records for each source location; (b) constructing supergathers to improve the noise separation techniques, and (c) summing the data for each source location

25. *(original)* The method of claim 10 further comprising separating the data into bins at small common depth point intervals and migrating the data thereby improving imaging and focusing.

26. *(original)* A method of processing seismic data generated by at least two seismic vibrators with a number of sweeps at least equal to the number of vibrators comprising the steps of

- (a) measuring a vibrator motion signal for each vibrator;
- (b) measuring the seismic signal;
- (c) computing a vibrator signature for said measured vibrator motion signal;
- (d) specifying a desired seismic data processing impulse response, wherein the high and low frequency portions of an amplitude spectrum of said impulse response taper to zero at a rate faster than does the high and low frequency portions of an amplitude spectrum of said vibrator motion signal;
- (e) computing a deconvolution matrix in the frequency domain that separates the earth response for each vibrator and replaces the individual vibrator signatures with the desired impulse response;
- (f) processing said seismic data and separating the data according to the individual vibrators using said deconvolution matrix.

27. *(original)* The method of claim 26, wherein said vibrator motion is the vibrator ground force signal.

28. *(original)* The method of claim 26 wherein said vibrator motion is approximated by a vibrator pilot signal.

29. *(original)* The method of claim 26, wherein small values of an amplitude spectrum of said impulse response are set equal to a threshold value.

30. *(original)* The method of claim 26, wherein small values of an amplitude spectrum of said impulse response are set less than a threshold value.

31. *(original)* The method of claim 26, wherein the vibrator signature is computed from the time derivative of said ground force signal.
32. *(original)* The method of claim 26, wherein said computation of said deconvolution filter involves an iteration in which zero phase and minimum phase impulse responses are analyzed to determine the suitability of said deconvolution filter to process high and low frequency data content in said seismic data.
33. *(original)* The method of claim 26, wherein a small amount of prewhitening noise is added to all frequency values of an amplitude spectrum of said impulse response
34. *(original)* The method of claim 26 wherein the frequency sweep increases linearly in time.
35. *(original)* The method of claim 26 wherein the frequency sweep decreases linearly in time.
36. *(original)* The method of claim 26 wherein the frequency sweep is a nonlinear sweep.
37. *(original)* The method of claim 26 wherein the frequency sweep is a random sweep.
38. *(original)* The method of claim 26 wherein different vibrators are energized by sweeps which are phase encoded.
39. *(original)* The method of claim 26 wherein different vibrators are energized by sweeps in which one vibrator a time is energized by a sweep with a 90 degree phase rotation relative to the phases of the other vibrators
40. *(original)* The method of claim 26 wherein multiple sweeps are used and the sweeps include in any order of phase rotations of $360/N$ degrees where N is an integer.

41. *(original)* The method of claim 39 wherein multiple sweeps are used and the sweeps include in any order of phase rotations of $360/N$ degrees where N is an integer.

42. *(original)* The method of claim 26 wherein the different vibrators are energized by sweeps covering different frequency ranges at different times.

43. *(original)* The method of claim 26 wherein the different vibrators are energized by sweeps which start at different times.

44. *(original)* The method of claim 26 wherein the location of the detectors is selected from the group comprising detectors on the surface of the earth, detectors suspended in the water, detectors on the water bottom, detectors in a wellbore, and a combination thereof.

45. *(original)* The method of claim 26 further comprising:

(a) separating the data from each vibrator into individual records for each source location;

(b) applying static corrections and differential normal move-outs (NMO) to each source location;

(c) summing the data for each source location.

~~46~~45. *(currently amended)* The method of claim 26 further comprising constructing supergathers to improve the noise separation techniques.

~~47~~46. *(currently amended)* The method of claim 26 further comprising separating the data into bins at small common depth point intervals and migrating the data thereby improving imaging and focusing.